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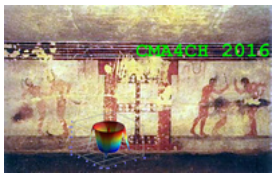

The Contribution of GIS for the Comprehension of Metallurgical Activities in Morocco

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Summary

This study develops an innovative documentation of scientific data, carried out by SEM – EDS, XRD and Micro-Raman analysis, through the use of GIS software with the intention to deepen the studies on the ancient metallurgical activities in the mines of Jebel Tabarouch, Negah, Mibladen, Aouli, Taza – Ain al Awda and Taza – Chikere in the frame of a project, director Dr. Lorenza Manfredi. The aim is the integration of archaeological studies regarding the influence of foreign cultures on the evolution and development of Metallurgy in the region of Northern and southern central-Atlas Rift from the prehistoric period to the Arab rule in the middle ages.

Introduction

The aim is to deepen the studies carried out metallurgical activities made anciently in the mines of Jebel Aouli, Mibladen, Negah, Tabarouch, Taza – Ain al Awda and Taza in Morocco – Chikere that has been the subject of several archaeological and archaeometric studies from 2012 to 2015, as part of the project between the ISMA-CNR and the University Moulay Ismail di Meknés. Conducted surveys were made as part of the bilateral project: "The Ancient mine of Morocco. Archaeological and archeometric study, from the mineral to the metallic artifact" between CNRST-Maroc and ISMA-CNR. While Aouan site has been affected by stratigraphic excavation as well as surface prospecting , carried out under a five-year collaboration agreement with INSAP-MAROCCO.
The aspects that allow to obtain important information about the metallurgical activity, can be summarised as follows:

- the different stages of the metals processing starting from their extraction to the artifact, including consideration of waste produced;
- the comparison of the different typology of waste due to the mines considered.
- the allocation of each step of the working process in each mine analyzed.

It was thus possible to realize a relationship among the archaeological and scientific documentation and the geographic coordinates of the respective reference sites.

Materials and Methods

Considering the aims of the project, it is important to focus attention on the following information:

- "Anvil" and "hammers", which indicate some tools used in ancient times during the various stages of metals extraction identified in Jebel Aouam site. Graphically it has been chosen a punctual form which has been associated symbol asterisk;
- "Ovens" and "Masonry structures", that identify traces due to the presence of ovens, furnaces and structures, pertinent with the various phases of metalworking, recognized at the Jebel Aouam mine. A structure, probably due to an oven, instead, can be attributed to Taza-Chikere mine. They were graphically depicted with a rumble as symbol;
- "Exploitation" and "firesetting", are referred to traces of exploitation and firesetting located, at the Jebel Aouam mine. They were graphically represented by a detailed form associated with the symbol of the equilateral triangle;
- "Mines and wells", which designate, the location of mines and wells examined and have been shown graphically with specific forms associated to isosceles triangle;
- "Slag Points", which indicate the places where are located the waste derived by metalworking process in the different mines. Three different layers are included, one for each analysis performed in this work (EDS, XRD and Micro-Raman), for the Jebel Aouam mine and three different layers, one for each

analysis carried out for mines Aouli, Mibladen, Tabarouch, Taza-Ain al-Awda and Taza Chikere. They have been graphically represented by punctual symbol of the pentagon.

The GIS software usually have tools that allow you to manually select the items of the geographical area in question and, consequently, the records in the table of attribute [1].

To request information relating to the various objects taken into account, three different levels of queries have been adopted.

The first is the most immediate and allows to identify the area of interest on the map, after which it is possible to use the GIS software interrogation control, denominated in QGIS "information items", to get detailed information about the objects on the map and view its attributes.

The second mode consists in the proposition of questions (filters or query) based on a SQL (Structured Query Language). These queries give the possibility to extract from the global dataset a reduced group of items, available either in the geographic map, either in the table.

For the third and last type of query, among the different types of symbology, that called for "unique values", which is also the one most used in GIS. In this legend the objects in one layer are labelled with a different symbol for each unique value present in a specific field in the Table of attributes.

Results

The interpretation of EDS, XRD and micro-Raman [2] data concerning the metal-working waste, and their interpretation according to QGIS software, have contributed significantly to several unpublished considerations. The display of the values of the isolevel curves is important for the definition of certain considerations about the positioning and movements in the various phases of the pyrometallurgical process. In anticipation of this study, the areas of Ighram Aousser, with a big amount of slags on the hills (slags ills), and the presence of the fortress ", each item sampled were documented with GPS coordinates, during the prospection of 2014. As can be seen in Figure 1, here also they recur the same typology of findings present in the Signal strand immediately identifiable by the same graphic symbol, but with the presence of an higher number of furnaces on the slag-hill of. In figure 1 it can be seen how there was a division of activity in different areas of Jebel Aouam mine, with a concentration of firesettings in the area of the slag-hill, that appears to be different from the extractive activity, concentrated mainly on the strand of the Signal. Most of the slags found, even those with stratigraphic testing found in the fortress, are related to the lead smelting.

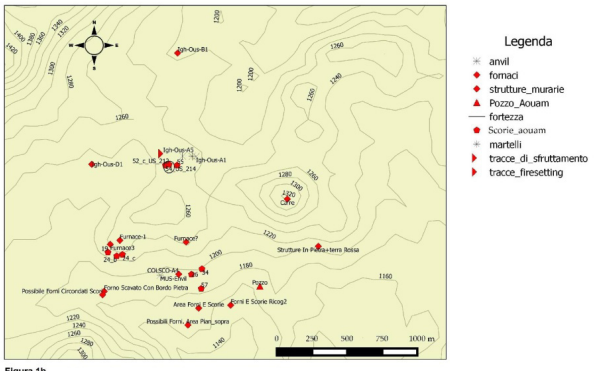

Fig.1; GIS processing of the finds at Ighram Aousser and the so-called slag-hill, in areas located at the Jebel Aouam mine

Conclusions

The modern setting of an archaeological project includes the establishment of a unified information system, able to treat the wide variety of information from different disciplines and manage an increasing quantity of excavation and laboratory data. If you consider the specific case of this study, the analytical information derived from a single fragment of pyrometallurgy chain are numerous and need, for their consistent interpretation, to be recombined with each other and connected through profiling and classifications. Often, too, the collection of relevant data in one place you can dwell in several years. The above makes the GIS, from the usage point of view for archaeological purposes, a complete tool both for the initial recognition of the research, both for the next stage, which the processing and management of the findings and the data generated by their study, archaeological, scientific and archaeometric.

References

1) Noti V.. 2014. GIS Open Source per geologia e ambiente. Analisi e gestione di dati territoriali e ambientali con QGIS. Dario Flaccovio Editore

2) D. Ferro et al., “Definizione di un protocollo analitico per lo studio archeometrico di materiali pirometallurgici del sito di Aouam Marocco”, in Manfredi L.I- Festuccia S., *AOUAM I*, Bologna 2016